

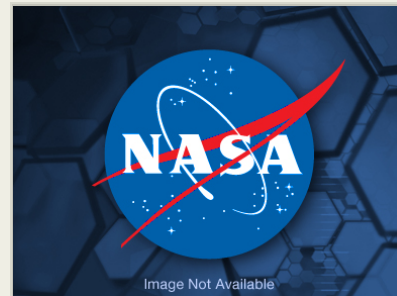
# Harnessing the Efficiency of O(1D) Insertion Reactions for Prebiotic Astrochemistry

Completed Technology Project (2016 - 2019)



## Project Introduction

We propose a THz spectroscopic study of the small prebiotic molecules aminomethanol, methanediol, and methoxymethanol. These target molecules are predicted as the dominant products of photo-driven grain surface chemistry in interstellar environments, and are precursors to important prebiotic molecules like sugars and amino acids. These molecules are also expected to be major contributors to the spectral line density in the submillimeter spectral surveys from the Herschel and SOFIA observatories. We will use our custom mixing source to produce these molecules through O(1D) insertion reactions with the precursor molecules methyl amine, methanol, and dimethyl ether, respectively. We will then record their rotational spectra across the THz frequency range using our existing submillimeter spectrometer. This research will increase the science return from NASA missions because the target molecules serve as tracers of the simplest organic chemistry that can occur in star-forming regions. This chemistry begins with methanol, which is the predominant organic molecule observed in interstellar ices. Methanol photodissociation leads to small organic radicals such as CH<sub>3</sub>O, CH<sub>2</sub>OH, and CH<sub>3</sub>. These radicals can undergo combination reactions on interstellar ices to form many of the complex organic molecules that are routinely observed in star-forming regions. Our target molecules aminomethanol, methanediol, and methoxymethanol are some of the simplest molecules that can form from this type of chemistry, and serve as tracers of ice mantle liberation in star-forming regions. These molecules also participate in gas-phase reactions that lead to amino acids and sugars, and as such are fundamentally important prebiotic molecules in interstellar environments. These types of small organic molecules also have high spectral line density, and are major contributors to line confusion in observational spectral surveys such as those conducted by Herschel and SOFIA. Therefore, the proposed research will aid in full data interpretation from Herschel and SOFIA observations. Currently there is no spectral information available for these molecules to guide observational studies, despite their importance in astrochemistry. This is because these molecules are difficult to study in laboratory settings due to their instability and reactivity. We are using highly exothermic O(1D) insertion reactions to produce these molecules in a supersonic expansion, and investigating the products using THz spectroscopy. This work builds on the work involved in our previous APRA award (Grant NNX11AI07G) "New THz Tools to Support Herschel Observations: Integrative Studies in Laboratory Spectroscopy, Observational Astronomy, and Chemical Modeling". In this previous award, we laid the groundwork for these experiments by constructing and benchmarking the spectrometer, designing and testing the molecular source used for the O(1D) reactions, and studying the proposed formation reactions for the laboratory work through computational studies. We have confirmed production of methanol from O(1D) insertion into methane, and then applied this chemistry to produce vinyl alcohol from ethylene. We have now also obtained preliminary spectra of aminomethanol. Here we propose to extend this work by finishing the aminomethanol characterization as well as examining



Harnessing the Efficiency of O(1D) Insertion Reactions for Prebiotic Astrochemistry

## Table of Contents

Project Introduction	1
Organizational Responsibility	1
Primary U.S. Work Locations and Key Partners	2
Project Management	2
Technology Areas	2
Target Destination	2

## Organizational Responsibility

### Responsible Mission Directorate:

Science Mission Directorate (SMD)

### Responsible Program:

Astrophysics Research and Analysis

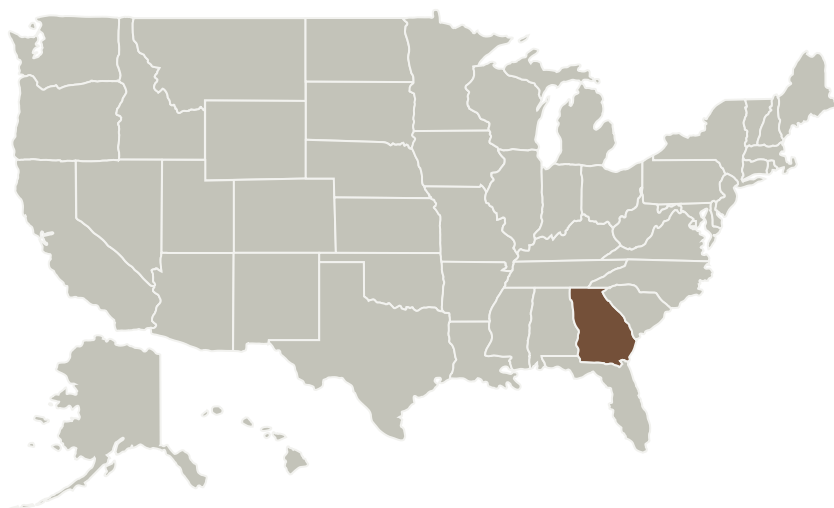
# Harnessing the Efficiency of O(1D) Insertion Reactions for Prebiotic Astrochemistry

Completed Technology Project (2016 - 2019)



methanediol and methoxymethanol during the next proposal period.

## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Emory University	Supporting Organization	Academia	Atlanta, Georgia

## Primary U.S. Work Locations

Georgia

## Project Management

**Program Director:**

Michael A Garcia

**Program Manager:**

Dominic J Benford

**Principal Investigator:**

Susanna L Widicus Weaver

**Co-Investigator:**

Holly Sommers

## Technology Areas

**Primary:**

- TX07 Exploration Destination Systems
  - TX07.1 In-Situ Resource Utilization
    - TX07.1.1 Destination Reconnaissance and Resource Assessment

## Target Destination

Outside the Solar System